ANNUAL REPORT 1987 - 1988

Lightning Mapper
Dr. Douglas Mach

Doppler Lidar
Mr. David Bowdle

ATMOSPHERIC SCIENCE AND REMOTE SENSING LABORATORY

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Of Alabama
In Huntsville

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TO: R. McNider

FROM: D. Bowdle

SUBJECT: 1987/1988 Annual Report

CONTRACT: NAS8-36279

DATE: April 20, 1988

The Atmospheric Science and Remote Sensing Laboratory in the Johnson Research Center (JRC) of the University of Alabama at Huntsville has been involved in research in conjunction with the Remote Sensing Branch (ED43) in the Earth Science and Applications Division of NASA's Marshall Space Flight Center. During the second contract year from April 1, 1987, to March 31, 1988, this research included two general areas. Each area is listed below, along with the JRC researcher responsible for coordinating work in that area, the sponsoring organization in ED43, and the related ED43 research mission.

1. **Lightning Mapper / Dr. Douglas Mach**
   ED43 Atmospheric Electricity Group
   Sensor Development Team / Earth Systems Observation
   Lightning Mapper Mission

2. **Doppler Lidar / Mr. David Bowdle**
   ED43 Doppler Lidar Group
   Sensor Development Team / Earth Systems Observation
   Laser Atmospheric Wind Sounder (LAWS) Mission

LIGHTNING RESEARCH

by Douglas Mach

I. Research Overview

A. Research Activities

During the contract year, scientific research on lightning and lightning hazards was carried out for the Atmospheric Electricity Group in the MSFC Remote Sensing Branch (ED43). These tasks included research on modeling the interaction of lightning optical pulses and cloud particles, estimating lightning hazard threats to the STS system, a small field project to determine the charge structure of winter and stratiform thunderstorms, and analysis of optical pulse data. These activities were performed in conjunction with the ED43 mission to develop a lightning mapper to be placed on one of the GOES-next operational satellites.

B. Key Results

1. Cloud Model

The task detailed here was to model the interactions of optical pulses and cloud particles to try to understand how the transmission of lightning pulses through clouds can alter their shape and spectral composition. The initial sub-task was to bring a simple cloud model program up to working order on a Fairchild Clipper computer. This sub-task was completed. The second sub-task, which was also completed, was to create a data base of optical output from the model cloud given different optical source locations.

2. Lightning Threats to the STS system

The goal of this task was to determine the chance of lightning damaging various parts of the STS system during the various phases of the system deployment, launch, and recovery. The lightning threats include the transportation of SRB segments between Utah and Kennedy Space Center, the transportation and assembly of the SRB segments at KSC, the transportation of the stacked STS system to the pad, the time spent on the pad, the fueling of the ET, the launch of the STS near thunderstorms, and the landing of the Orbiter after the mission. The analysis was carried out and the results presented to the leader of the Atmospheric Electricity Group.

3. Winter and Stratiform Thunderstorm Research

The purpose of this task was to determine the charge structure of winter time and stratiform thunderstorms. To accomplish this task, a mobile laboratory was modified to launch sounding balloons into active thunderstorms at remote sites. The sounding system was modified to measure the electrical structure of the thunderstorm. The instrumentation of the mobile laboratory was completed and several practice launches were made. In addition, a fully instrumented data launch was also made. The program is in a state that it can be restarted next year.

4. Optical Pulse Analysis

For this task, a program that will perform automatic analysis of optical pulse data was corrected and improved so that it would work more efficiently. The program finds all optical pulses in a digitized data set and determine the rise, fall, and total time of each pulse. The information for all pulses in the data set is then output so that statistical analysis can be performed on the reduced data set.

C. Travel

None

II. Publications and Presentations

Published:

Idone, V. P., R. E. Orville, **D. M. Mach**, and W. D. Rust (1987). The propagation speed of a positive return stroke. Geophys. Res. Lett., 14, 1150-1153.

Submitted for Publication:

Mach, D. M. and W. D. Rust. An Electronic Technique for Measuring Lightning Channel Propagation Velocities from a Mobile Laboratory. Submitted to J. Oceanic and Atmos. Tech.

Near Completion:

Mach, D. M. and W. D. Rust. Return Stroke Velocities and Currents Using a Solid State Silicon Detector System. To be submitted to J. Geophys. Res.

SENSOR TECHNOLOGY

by Jeffrey M. Marx

I. Overview

A. Activities

During the contract year, sensor development was undertaken for the Atmospheric Electricity Group within NASA's Remote Sensing Branch(ED43) at Marshall Space Flight Center. Among tasks completed were characterization and upgrade of the EBERT 1/2(HRS) and 1/8(BBS) meter spectrometers, characterization and redesign of the Dual Optical Pulse Sensor(DOPS), preliminary work for the ER-2 pallet redesign, 1984 lightning spectral data research, the Winter INternational Thunderstorm Electricity Research project (WINTER), and preliminary Image Technology Lab(ITL) work.

B. Results

1. EBERT Spectrometers

The task was to characterize and improve the resolution of the HRS and BBS. Various spectral sources covering a wide bandwidth were used as point and diffuse sources. The resolutions were determined for both instruments. It was discovered that the HRS had a focusing problem which manifested itself as a frequency shift for a point source and a resolution degradation for a diffuse source. Refocusing the instrument increased resolution by solving this problem.

2. Dual Optical Pulse Sensor(DOPS)

The DOPS is a pair of a.c. coupled silicon photodiodes masked with interference filters and appropriate optics, and is used to study the rise times of lightning pulses within prescribed bandwidths. Due to a concern that sensor performance was electronics limited to 4 microsecond rise times(10%-90%), a study was undertaken and electronics redesigned to provide 1 microsecond performance. This was driven by research indicating that lightning rise times could be on the order of 5 microseconds. The end product demonstrated 1.5 microsecond rise times.

3. Preliminary ER-2 Pallet redesign

In preparation for the jump from the U-2 aircraft to the ER-2, the HRS, BBS, and the pallet itself were entered into the Intergraph IGDS CAD System. The goal is to reintegrate the instruments onto the pallet for upcoming ER-2 flights.

4. 1984 spectral research

The task was to write a paper based on 1984 U-2 lightning spectral data. Software was developed to compare spectral data with corresponding video. An in depth comparison for many cases is planned in an effort to complete this project.

5. the Winter INternational Thunderstorm Electric Research project (WINTER)

Four instruments were built or modified and integrated onto the Thunderstorm Utility Bus(TUB) for use in WINTER to support mobile balloon launches. Included were fast and slow antennas, an electric field mill, and an optical detector all of which were multichannel instruments. The outputs were digitized and stored on 14 channel magnetic tape on board the TUB. The purpose was to support mobile balloon launch and tracking.

6. Image Technology Lab(ITL)

The ITL is a newly created lab which will support characterization, modification, calibration, and design work on all of NASA's optical detectors and sensors. Procurements, etc. for the ITL have been ongoing for several months. The ITL should be operational sometime this summer.

C. Travel

None

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SUBJECT: 1987/1988 Annual Report

Enclosed is the annual report from the Remote Sensing Branch (ED43) to be included in the 1987/1988 Annual Report Summary. Listed below are the title, name, and affiliation of each author.

1. **Global Aerosol Modeling**
   by David Bowdle
   Earth Systems Observation/Doppler Lidar Group

GLOBAL AEROSOL MODELING

by David Bowdle

I. RESEARCH OVERVIEW

A. Research Activities

Research activities during this contract year were primarily aimed at the development of a global model of aerosol backscatter. This work was carried out for the Doppler Lidar Group in the Earth Systems Observation Team of the MSFC Remote Sensing Branch (ED43), under NASA's GLObal Backscatter Experiment (GLOBE) program. The results of this work are being used by ED43 in design and performance studies of NASA's prospective Laser Atmospheric Wind Sounder (LAWS).

Aerosol research tasks under this contract involved 1) designing the GLOBE program; 2) organizing and documenting meetings of the GLOBE Scientific Working Group (SWG); 3) developing a global-scale aerosol model; 4) publishing and presenting the results of the research; 5) providing technical consultation concerning the effects of atmospheric aerosols on LAWS performance; 6) developing an aerosol research plan using LAWS in NASA's prospective Earth Observing System (Eos); 7) developing general-purpose data analysis and display software for a desktop microcomputer; and 8) coordinating periodic progress reports by other investigators under this overall Remote Sensing contract.

B. Key Results

1. GLOBE Program Design

The goal of this task was to refine the scientific basis for the design of the overall GLOBE research program, to refine the GLOBE research program as needed, to document the research program, and to work with MSFC and NASA Headquarters to implement the refined research program. All of these tasks have been accomplished except for the complete documentation of the program. Preparation of a test plan document for the GLOBE survey flight has been initiated.

The rationale for GLOBE has been based on a working hypothesis involving a global-scale aerosol background with an invariant scattering mixing ratio and a high frequency of occurrence. Results of GLOBE research during the previous year have confirmed the existence of such a background in the mid-latitudes and the tropics. Background scattering mixing ratios show little variability in these regions, even during massive volcanic aerosol injections into the stratosphere. Background conditions occur frequently enough that they must be taken into account in LAWS design and operation.

2. GLOBE Meetings

The goal of this task was to provide periodic critical reviews of recent research results from ongoing GLOBE studies and of plans for new GLOBE measurement and modeling research. During the contract year, three meetings of the GLOBE SWG were held to accomplish this purpose. Activities in this area included organizing the technical sessions, coordinating the meetings and technical sessions, giving several of the technical presentations, documenting the presentations, providing technical summaries of the key results, and preparing periodic newsletters.

3. GLOBE Model

The goal of this task was to refine the existing model of the global-scale background aerosol backscatter at CO_2 wavelengths. Activities under this task involved designing, or evaluating the design of, various backscatter measurement and modeling experiments for GLOBE; maintaining technical liason with GLOBE Principal Investigators (PI); reviewing PI proposals, reports, papers, and data summaries; working with visiting aerosol scientists (Mr. Charles A. Brock, PhD candidate, University of Washington, Universities Space Research Association [USRA] Summer Intern); compiling the results of various GLOBE researchers; and synthesizing the results into the GLOBE model.

A significant portion of this activity involved detailed study of aerosol backscatter measurements at 10.6 um wavelength from an airborne continuous wave focused CO_2 lidar operated by the Royal Signals and Radar Establishment (RSRE). In conjunction with Dr. Jeffry Rothermel (USRA), optimized algorithms were developed for detecting and accurately measuring very low backscatter coefficients with the RSRE lidar. This work has led to the development of six journal papers (three submitted, three near submission), three conference papers, and one technical report, with more publications expected in the near future.

4. Publications and Presentations

The goal of this task was to present the results of the global aerosol modeling research in open scientific forum. Activities under this task involved preparation of papers for technical journals (three submitted, three near submission, and others in various stages of preparation), presentations in scientific conferences (eight papers, six of which appear in conference preprints, and organization of a GLOBE technical session), other technical reports (two published, others in various stages of preparation), and service as Lead Guest Editor for a special GLOBE issue of the Journal of Geophysical Research - Atmospheres. In addition, three papers were reviewed for other scientific publications.

Activities as Guest Editor involved soliciting papers from the GLOBE research team, organizing the issue, coordinating all of the peer reviews, and reviewing all manuscripts dealing with aerosol microphysics or modeling. Up to 28 papers are expected for the special issue. Currently, 12 papers have been received and sent out for review. Full reviews have been received on four of the papers. Since September of 1987, when the Guest Editor appointment was made by the GLOBE SWG, this activity has represented a major portion of the work under this contract.

5. Consultation for LAWS

The goal of this task was to evaluate the impact of atmospheric aerosol properties on design alternatives and programmatic decisions for LAWS. Activities under this task primarily involved attendance at the Fourth Meeting of the LAWS SWG and at an endless succession of internal LAWS meetings at MSFC.

6. LAWS/Eos Proposals

The goal of this task during the current contract year was to define a preliminary program of aerosol research using LAWS in the Eos framework in the 1990's. This task was accomplished. The prospective program involves measurements of the global-scale aerosol background and developing global budget models of the background. During the upcoming contract year, this concept will be developed into a proposal for a "Team Member" position on the new Eos/LAWS SWG. Some related research efforts will be included in a separate "Interdisciplinary" Eos proposal dealing with the transport of mineral dust to the ocean surface.

7. Computer Software Development

Several of the tasks under the global aerosol modeling portion of this contract require the development of general purpose, high-speed color graphics software. For most of the contract year, little progress could be made in this area because the only routinely available microcomputer was an IBM PC with monochrome graphics. In late February 1988, an AST Premium 286 microcomputer, a NEC Multisync monitor, and associated software were obtained. Improvements in the speed of software development have been breathtaking. High-resolution/high-speed color graphics are now routinely available. In addition, major improvements have been made in the speed and efficiency of manuscript and presentation preparation.

8. Contract Reports

Mr. Bowdle was responsible for coordinating and editing periodic progress reports under this contract. During the contract year, four quarterly reports and one annual report were prepared.

C. Travel

Guntersville, AL, May 4-6, 1987. Coordinated and participated in the Third Meeting of the GLOBE SWG and the Fourth Meeting of the LAWS SWG.

Aspen, CO, July 25-31, 1987. Presented invited paper and other papers at Fourth Conference on Coherent Laser Radar: Technology and Applications, sponsored by Optical Society of America.

Vancouver, British Columbia, August 11-18, 1987. Presented paper at Symposium on Aerosols and Climate in 1987 Meeting of International Association of Meteorology and Atmospheric Physics / International Union of Geodesy and Geophysics. Also participated in a meeting of the Joint Working Group on the International Aerosol Climatology Project.

Tucson, AZ, September 14-17, 1987. Coordinated and participated in Fourth Meeting of GLOBE SWG and gave several presentations on GLOBE activities.

Anaheim, CA, February 2-6, 1988. Presented paper at Third Conference on Satellite Meteorology and Oceanography, sponsored by American Meteorological Society.

Oakland, CA, February 6-10, 1988. Coordinated and participated in Fifth Meeting of GLOBE SWG and gave several presentations on GLOBE activities.

II. Publications and Presentations

A. Journal Publications

1. Completed

Rothermel, J., **D.A. Bowdle**, J.M. Vaughan, D.W. Brown, and A.A. Woodfield, 1989: "Calculation of aerosol backscatter from airborne CW focused CO_2 Doppler lidar measurements, Part 1, Algorithm description." Submitted to special GLOBE issue of J. Geophys. Res.

Rothermel, J., **D.A. Bowdle**, and J.M. Vaughan, 1989: "Calculation of aerosol backscatter from airborne CW focused CO_2 Doppler lidar measurements, Part 2, Algorithm performance." Submitted to special GLOBE issue of J. Geophys. Res.

Vaughan, J.M., **D.A. Bowdle**, R. Callan, and J. Rothermel, 1988: "Spectral analysis, digital integration, and measurement of low backscatter in coherent laser radar." Submitted to Appl. Opt.

2. Pending

Bowdle, D.A., J. Rothermel, J.M. Vaughan, D.W. Brown, M.J. Post, and R. Foord, 1989: "Aerosol backscatter measurements with airborne and ground-based CO_2 Doppler lidars over the Colorado High Plains, Part 1, lidar intercomparison." To be submitted to special GLOBE issue of J. Geophys. Res.

Bowdle, D.A., J. Rothermel, J.M. Vaughan, and M.J. Post, 1989: "Aerosol backscatter measurements with airborne and ground-based CO_2 Doppler lidars over the Colorado High Plains, Part 2, backscatter structure." To be submitted to special GLOBE issue of J. Geophys. Res.

Rothermel, J., **D.A. Bowdle**, J.M.Vaughan, and M.J. Post, 1988: "Evidence of a tropospheric aerosol backscatter background mode." To be submitted to Nature.

B. Conference Presentations

1. Fourth Conference on Coherent Laser Radar: Technology and Applications, Aspen, CO, July 25-31, 1987

Bowdle, D.A.: "A global-scale model of aerosol backscatter at CO_2 wavelengths"

Bowdle, D.A. and D. E. Fitzjarrald: "The GLObal Backscatter Experiment (GLOBE) program" (invited paper)

Bowdle, D.A., W. D. Jones, A. D. Clarke, S. A. Johnson, and D. E. Fitzjarrald: "Mauna Loa Aerosol Backscatter Intercomparison Experiment (MABIE)"

Patterson, E.M., and **D.A. Bowdle**: "Use of aerosol microphysical measurements to model IR backscatter in support of GLOBE"

Rothermel, J., J.M. Vaughan, and **D.A. Bowdle**: "Algorithm to calculate aerosol backscatter from airborne CW focused CO_2 Doppler lidar measurements"

Vaughan, J.M., D.W. Brown, J. Rothermel, and **D.A. Bowdle**: "Measurements of aerosol backscatter at CO_2 wavelengths with the airborne Laser True Airspeed System (LATAS)"

2. Symposium on Aerosols and Climate
International Association of Meteorology and Atmospheric Physics
International Union of Geodesy and Geophysics
Vancouver, British Columbia, August 11-18, 1987

Bowdle, D.A., J. Rothermel, and J.M. Vaughan: "Micro-scale to global-scale variability of atmospheric aerosol backscatter at 10.6 micrometers wavelength"

3. Third Conference on Satellite Meteorology and Oceanography
Anaheim, California, February 1-5, 1988

Bowdle, D.A., 1988: "The GLObal Backscatter Experiment (GLOBE) measurement and modeling program"

C. Other Publications

1. Completed

Bowdle, D.A., W.D. Jones, A.D. Clarke, S.A. Johnson, and D.E. Fitzjarrald, 1987: "Mauna Loa Aerosol Backscatter Intercomparison Experiment (MABIE)", in Geophysical Monitoring for Climatic Change, No. 15, Summary Report 1986, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Research Laboratories, Boulder CO, December 1987. 137-139.

Vaughan, J.M., D.W. Brown, P.H. Davies, R. Foord, J. Cannel, C. Nash, A.A. Woodfield, **D.A. Bowdle**, and J. Rothermel, 1987: Atmospheric Backscatter at 10.6 um: A Compendium of Measurements Made Outside the United Kingdom by the Airborne LATAS Coherent Laser Radar Velocimeter: RSRE Report 87002, Royal Signals and Radar Establishment, Great Malvern, United Kingdom, May 1987.

2. Pending

Patterson, E.M., and **D.A. Bowdle**, 1988: Use of Aerosol Microphysical Measurements to Model IR backscatter in Support of GLOBE. To be submitted as a Universities Space Research Association Contract Report.

Bowdle, D.A., and D.E. Fitzjarrald (Eds), 1988: GLOBE Survey Program Test Plan. In preparation.

D. Reviews

two articles for Symposium on Aerosols and Climate, 1987 Meeting of International Association of Meteorology and Atmospheric Physics / International Union of Geodesy and Geophysics, Vancouver, British Columbia, August 11-18, 1987

one letter for Applied Optics

full reviews for all aerosol microphysics and modeling papers for GLOBE special issue of Journal of Geophysical Research - Atmospheres, editorial review for all other GLOBE papers

E. GLOBE SWG Presentations

1. Third Meeting of the GLOBE Scientific Working Group
Guntersville, Alabama, May 4-5, 1987

Bowdle, D.A.: "GLOBE backscatter model"

Bowdle, D.A., J. Rothermel, J.M. Vaughan, and M.J. Post: "Comparisons of aerosol backscatter from ground-based and airborne CW CO_2 lidars"

Bowdle, D.A., A.D. Clarke, S.A. Johnson, W.D. Jones, and D.E. Fitzjarrald: "Mauna Loa Aerosol Backscatter Intercomparison Experiment (MABIE)"

2. Fourth Meeting of the GLOBE Scientific Working Group
Tucson, Arizona, September 14-16, 1987

Bowdle, D.A.: "GLOBE data plan"

Bowdle, D.A.: "GLOBE model update"

Bowdle, D.A., J. Rothermel, J.M. Vaughan, and D.W. Brown: "Data update on RSRE aerosol backscatter measurements with LATAS"

Bowdle, D.A., W.D. Jones, S.A. Johnson, and A.D. Clarke: "Final report on the Mauna Loa Aerosol Backscatter Intercomparison Experiment (MABIE)"

Bowdle, D.A., and E.M. Patterson: "New GLOBE microphysics studies"

Bowdle, D.A., for P. Flamant: "French participation in GLOBE"

Bowdle, D.A., for S.A. Johnson and A.D. Clarke: "Aircraft integration requirements for the Argonne real-time Attenuated Total Reflection impactor and the University of Hawaii preconditioned optical particle counter"

Fitzjarrald, D.E., for **D.A. Bowdle**: "The GLOBE program"

3. Fifth Meeting of the GLOBE Scientific Working Group
Oakland, California, February 8-10, 1988

Bowdle, D.A., for S.A. Johnson: "Attenuated Total Reflection Impactor"

Bowdle, D.A., for B.A. Bodhaine: "Multi-wavelength Integrating Nephelometer"

F. GLOBE SWG Publications

1. Proceedings

Bowdle, D.A.(Ed), 1987: Proceedings: Third Meeting of the GLOBE Scientific Working Group, Guntersville, Alabama, May 4-6, 1987, Birch and Davis Associates, Silver Springs, Maryland, 223 pp.

Bowdle, D.A. (Ed), 1988: Proceedings: Fifth Meeting of the GLOBE Scientific Working Group, Oakland, California, February 8-10, 1988, Birch and Davis Associates, Silver Springs, Maryland, 190 pp.

2. Summaries

Bowdle, D.A., 1987: Summary of Third GLOBE Meeting, Guntersville, Alabama, May 4-5, 1987, University of Alabama at Huntsville, Huntsville, Alabama, 9 pp.

Bowdle, D.A., and D.E. Fitzjarrald (Eds), 1988: Technical Session Summaries, Fifth Meeting for the GLObal Backscatter Experiment (GLOBE), Oakland, California, February 8-10, 1988, Birch and Davis Associates, Silver Springs, Maryland, 9pp.

3. Newsletters

Bowdle, D.A., 1987: GLOBE Newsletter, Vol. 1, No. 1, June 1, 1987, University of Alabama at Huntsville, Huntsville, Alabama, 6 pp.

Bowdle, D.A., 1987: GLOBE Newsletter, Vol. 1, No. 2, December 15, 1987, University of Alabama at Huntsville, Huntsville, Alabama, 6 pp.